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THE IMPACT OF TRADE AND TRANSPORT SERVICES ON THE ENVIRONMENT IN AFRICA

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Abstract: This study investigates the impact of trade and transport services on the environment in Africa. Secondary data for 21 countries spanning 2000 and 2014 were used and analysed using POLS, FE, RE and PMG. These techniques revealed diverse results. The Hausman test was used to decide between FE and RE in the study. The Hausman test accepts the FE result due to it 5% significant result. The POLS reveal that trade and economic growth reduces degradation in Africa, while transport services in the export and import sector and energy consumption increases degradation. Notably from the FE result, trade, energy consumption and economic growth showed a positive impact on environmental degradation in Africa, while transport services in the import and export sector reduces environmental degradation. For the PMG result, findings show that in the long-run, trade, transport services (export and import), energy consumption, and economic growth increase degradation in Africa. This implies as these activities increases in the long run, there are no measure to ensure environmental quality. In the short-run, trade and transport services in the import sector reduce degradation as many of the importation is dominated by improved technology products, while transport services in the export sector, energy consumption and economic growth positively impact on environmental degradation in Africa. The study concludes a mixed effect of trade and transport services on the environment in Africa. A major recommendation is that more energy efficient technologies should be used in Africa to meet the sustainable environment goal and this can be done by reviewing trade policy to encourage inflow of improved technology into the economies.

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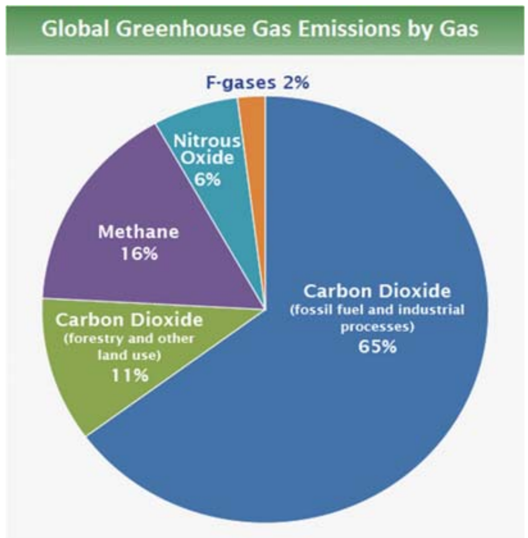
1. Introduction

Among factors that increase the concentration of Green-House-Gas (GHG) emissions in the atmosphere, human activities and energy are significant over the years (Rehman and Rashid, 2017). Albeit, energy is regarded as the engine of development in every economy, but its production, use and products are considered harmful to the environment from resource use and pollution, which impedes sustainable development (Rehman and Rashid, 2017). The environment is also seen as a unit under negative externalities induced by sectors among which transport is considered significant most especially in Africa (Chirisa, et al., 2015). Noted by Chirisa et al., (2015) in line with the Environmental Protection Agency (EPA), environmental impact of transport services is categorised intp five groups: infrastructure construction, maintenance and abandonment, vehicle and parts manufacture, vehicle travel, vehicle maintenance and support and disposal of used vehicles and parts within highway, rail, aviation and maritime modes of transports. Similar to Africa, Nunes, et al. (2019) identified transportation as the main source of increasing Green House Gases (GHG) in the European zone as it have several important secondary effect on the societies and economies.

According to the Intergovernmental Panel on Climate Change (IPCC) (2007), the most significant emission is CO_2 Methane (CH_4) and Nitrous Oxide (N_2O), emitted through fossil fuel combustion, deforestation, degradation of soils and clearing of land for agricultural purposes. While fluorinated gases are the least contributor of emission caused by refrigeration, industrial activities and from consumer products that emit gases like hydrofluorocarbons (HFC's), sulfur hexafluoride (SF_6) and perfluorocarbons (PFC's) (Rehman and Rashid, 2017). From Figure 1, it can be argued that F-gases contributes 2% which is the least of the total, Nitrous Oxide contributes 6%, the second least and carbon dioxide contribute the most, 76%. Carbon dioxide emission from fossil fuels and industrial processes claims about 65% of the total, while, CO_2 from forestry and other land usage contributes 11% of the total emission.

Figure 1: Global GHG Emissions by Gas



Source: IPCC, 2014; United States Environmental Protection Agency, 2017

Before the 19th century, IPCC (2007) reported that accumulated CO_2 ranges between 260 and 290 parts per million (ppm) and continuously increases. In 2017, accumulated CO_2 level is measured at 385ppm and on average increases by 2ppm yearly (IPCC, 2007; and Rehman and Rashid, 2017). However, the increase can be reduced through conservation and efficient use of energy resources, reforestation and change in the pattern of soil usage.

Recently, in most African countries, with the aim of increasing human welfare, the level of activities and the rural residents' migration to the urban centres to change their system of production (agricultural to industrialized) is increasing with a positive turn on the demand for conventional energy sources and the amount of emission in the environment. This occurrence validates the environmental Kuznets hypothesis (EKC) in the context of Africa (Rehman and Rashid, 2017). Rehman and Rashid (2017) further explained that the effect of population migration could be directly/indirectly positive or negative. Directly positive, population impact occurs when the increase in population increases the consumption of goods and services that can be recycled effectively. This is however not favourable in the context of Africa as most of the recycling facilities are not in place. Although, few African countries such as Rwanda are cautioning the emission through its prohibition on the use of plastic bags[1] and biodegradable bags circulating in Zambia to reduce the use of plastic bags among others[2]. Therefore, indirectly, reduces environmental pollution. On the negative side, increase in rural-urban migration directly results in demands for more houses, in the process of building new houses, deforestation occurs and indirectly influences degradation level in the environment.

Detached human activities and energy usage are identified by Kuznets (1955) as factors that influence degradation of the environment at the early stage of development in developing countries. Other factors identified as a contributor to degradation of the environment includes population, trade activities such as importation of oil products, technologies, agriculture (intensive) and industrialization (chemical industries), transport services, health status, and education level among others (Dietz and Rosa, 1994). Rethinking the model, Dietz and Rosa (1994) mapped guidelines for modifying the model with the later factors listed. In this study, more focus is on trade and transport activities impact on environmental degradation in Africa. This is spurred by the increasing trade activities aided by transportation via various means: land, air, ship among others. Also noted, as people migrate with the aim of having a better life in the urban centres, the migration is aided by transportation and other development factors such as Radio, TV, ICT/Internet which allows the villages to know about the urban city's lifestyle. People get engaged with activities to sustain themselves (for example, A large proportion of smallholder farmer sustain themselves through subsistence farming and barter economy without being connected to the local, regional or national marketplaces) for a while which in most cases through trade. Trade also is made effective via transportation for delivery. Since the means (transportation) is powered by fossil fuel products, it is expected to contribute to degradation of the environment. In Figure 2, industry and transportation contributes about 21% and 14% to degradation, while electricity and heat production and agriculture, forestry and other land use contribute 25% and 24% degradation respectively. This implies that jointly, industry and transportation sector contribute about 35% of global greenhouse gas emissions which is a very significant percentage of the total.

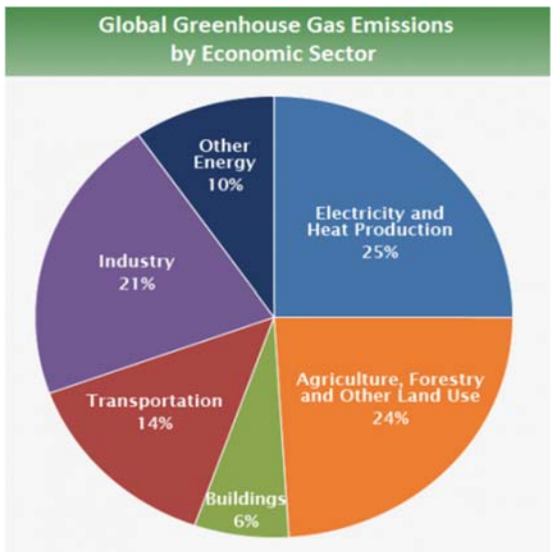
In this study, panel econometrics techniques: Pooled Ordinary Least Squares (POLS), Fixed Effect (FE), Random Effect (RE), and the Pooled Mean Group (PMG) is adopted for the data analysis. The methods have a robust view of trade and transport services impact on degradation of the environment in Africa. POLS accepts that the independent variables are non-stochastic, the error term is uncorrelated with the independent variables, homoscedasticity, and strict exogeneity of the independent variables. FE controls for time-invariant differences, it has less omitted variable bias and adds a dummy variable for each predictor. RE does not control time-invariant differences in the data used. FE and RE both assume time-invariant

[1] https://www.cbd.int/financial/fiscalenviron/Rwanda-EFR.pdf

[2] http://www.daily-mail.co.zm/no-plastic-day-one-bag-at-a-time/

heterogeneity among groups is uncorrelated with error term. FE therefore falls short as it limits what can be estimated through its control for potential omitted variable bias, while RE does not control for omitted variable bias. PMG allows the intercepts, short-run coefficients, and error variances to differ freely across groups, but constrains the long-run coefficients to be the same. The model assumes long-run similarities given budget or solvency constraints, arbitrage conditions, or common technologies influencing all groups in a similar way (Pesaran, *et al*., 1999). The PMG assumptions therefore fill the gaps in POLS, FE and RE model.

Figure 2: Global GHG Emissions by Economic Sectors



Source: IPCC, 2014[3]; United States Environmental Protection Agency, 2017

The rest of the study is structured as follow. Section 2 reviews related literatures to the study. Section 3 presents the econometric approach and data used. Section 4 discusses the results. Section 5 presents the conclusion and recommendations.

2. Literature Review

The basic theory of this study rests on the environmental theories of Kuznets (1955) and Dietz and Rosa (1994). Kuznets (1955) is of the opinion that environmental degradation in an economy is as a result of increased economic activities and energy used at the early stage of development. The theory maintains a position that, as an economy aims to increase in terms of growth and development, the focus is more on

[3] https://www.ipcc.ch/report/ar5/wg2/

productivity which requires more hands and technology to achieve. In this process, more resources that are environmentally unfriendly are used. However, the theory has been criticized by scholars that the findings are limited in terms of the factors considered as determinants of environmental degradation. Among the scholars, Malthus (1798) submitted that the geometric growth of population may outstrip the arithmetic growth of the means of survival (subsistence). Malthus argued that the population growth is exponential in nature, while the growth in subsistence is linear. This, however, suggests that, population doubles the growth in subsistence, and if not checked may lead to poverty, therefore impacting negatively on the environment. Similarly, Daly (1983) argued that constant population and poverty level increase are the factors that stimulates environmental degradation. Another notable theory on the modification of Kuznets submission is Ehrlich and Holdren (1971), who revisited the relationship between population, resources and the environment generally known as IPAT (Impact, Population Affluence and Technology) model by considering the anthropogenic environmental change. They map out guidelines for modification and suggest ways to supersede the IPAT model. Reformulating *"I"*, Ehrlich and Holdren (1971) submitted that, rather than focusing on human activity as an input in the environment, it can be modified by looking into import and export activities of a nation across borders and its international division of labor via trade. Reformulating "P", Ehrlich and Holdren (1971) argued that population should be decomposed considering age groups to know the impact of each class. Reformulating "A", it was argued that, rather than per capital output, health status is a good measure of the parameter. The theorists noted that Physical Quality of Life Index (PQLI) which combines infant mortality, literacy and life expectancy can be used, but was criticized on its arbitrary units, while life expectancy at birth was considered to be more sufficient as it is a function of the age specific mortality rates occurring in a population, and thus can reasonably be interpreted as a key quality of life indicator. Finally, reformulating "T", they expanded the existing narrow theoretical assumption of "T" to mean just technology, but everything else not included in the model, such as: The Happiness Index (attitudes), values, institutional arrangements among others, of the population. The arguments among the theories have spurred the interest of researchers to test empirically reality of the theories submission. Dietz and Rosa (1994) however developed a stochastic version of IPAT model to estimate the parameters suggested by Ehrlich and Holdren (1971) with addition of political and economic institutions, and attitudes and beliefs as explanatory variables. Dietz and Rosa (1997), York et al. (2003), Aguir-Baragaoui, et al., (2014) and da Silva, et al., (2019) also reviewed the theory in the same direction.

Empirically, Kim, *et al*. (2018) studied the effect of trade on environmental degradation in 131 developed and developing countries. The study realized a strong beneficial effect running from trade flow to the developed countries environment and a negative effect running from trade flow to the developing countries environment. This implies that trade flow has a positive and negative effect on the environment of developed and developing countries respectively. In an evidence from transition economies, Halicioglu and Ketenci (2016) submitted that international trade positively and significantly influence the environmental quality of Estonia, Turkmenistan and Uzbekistan, and ordinarily effect environmental quality of Armenia, Kyrgyzstan, Latvia, and Russia. On the other hand, Le *et al*. (2016) argued from a panel study of 98 countries that trade openness causes particulate matter emissions to rise in all income groups of countries.

Studying nine oil exporting countries, Hasanov *et al*. (2018) noticed that trade does not have any effect on territory-based carbon emissions, but only influence consumption based carbon emissions in both the long-run and short-run. Huang *et al*. (2017) noted for the economy of China that importation of primary goods from the African continent improve value generation, create jobs, and cause environmental degradation. In an evidence from 14 origin countries and 39 host countries, Kahouli and Omri (2017) revealed that environmental degradation negatively and significantly influence trade, while the link between foreign direct investment and environmental degradation is negative and insignificant.

Data from 105 countries as shown by Shahbaz *et al* (2016) reveals that trade openness reduce carbon emissions in the countries. The study further found out that in the long-run, trade openness granger-cause carbon emissions for high income and low income countries, and have a feedback effect on carbon emissions for the global panels and middle-income country panel. In the same vein, Al-Mulali and Ozturk (2015) observed that trade openness has a long-run positive effect on ecological footprint of 14 MENA countries. In addition, Shahzad *et al*. (2017) realized that trade openness contributions to the increase in carbon emissions in Pakistan is significant. On the other hand, Ertugrul *et al*. (2016) studied top ten carbon emitters in developing countries that trade openness has positive significant impact on carbon emissions inTurkey, India, China and Indonesia, while in Thailand, Brazil and Korea, trade openness has no significant effect on environment. Hossain (2012) claimed that trade openness has negative effect on carbon emissions in the long-run in Japan.

Arvin *et al*. (2015) identified long-run link between transportation intensity and carbon emissions in all G-20 countries. Obtaining data from 75 countries to form four panels which include global, high income, middle income and low income countries, Saidi and Hammami (2017) demonstrated that freight transport significantly impact on environmental degradation, while environmental degradation has a weak statistically insignificant effect on freight transport in all the the four panels. Yoon *et al*. (2018) observed from the study of 14 countries that, China's transportation services has a significant positive impact on carbon emissions through their production activities, while the rise in the demand for international transportation services significantly increase carbon emissions in United States and other Asia countries. Alshehry and Belloumi (2016) discovered a bidirectional causal link between road transport energy consumption and transport carbon emissions, which implies that road transport energy consumption contributes to environmental degradation in Saudi Arabia.

Analyzing the factors responsible for transportating greenhouse emissions, Xu *et al*. (2018) observed that population density, land use mix, road connectivity and bus accessibility are factors that aids transportation of greenhouse gas emissions in Xiamen City, China. Wang *et al*. (2014) empirically submitted that the future rises in energy consumption of China's transportation sector will cause environmental degradation to rise in the future.

Studying the means of minimizing carbon emissions from transportation, Chaturvedi and Kim (2015) showed that the use of global electricity-based public rail transportation system negatively impact on environmental degradation via the reducting energy consumption. This implies that global electricity-based public rail transportation system serves as a means of reaching global climate mitigation policy goals. El-Fadel and Bou-Zeid (1999) revealed that fleet improvement, fuel quality regulations, technology improvement, and reduction of activity volume via better urban planning and better public transport will cause Lebanon's transportation of greenhouse gas emissions to reduce by 31% in 2020. In the United State of America, Campbell *et al*. (2018) found out that reduction in fuel consumption by some transportation modes and the adoption of strigent regulations will cause emissions from transportation (such as CO, NOx, VOC, NH_3, SO_2, PM_{10}, $PM_{2.5}$, PEC, and POM) to reduce in the future. Choi and Roberts (2015) confirmed that carbon emissions decrease in the United States via technological innovation, and alternative transport energy sources.

Bokpin (2016) submitted that the relationship between foreign direct investment and environmental sustainability is linear and negative. In addition, Boutabba *et al*. (2018) discovered that trade in intermediate goods has a positive effect on carbon emissions in the long-run, while in the short-run, there is a unidirectional causality running from trade in intermediate goods to carbon emissiions in 17 Sub-Saharan African countries. On the effect of transportation services on environmental degredation, Tongwane *et al*. (2015) noticed that road transport emissions increase on yearly basis by 2.6% and 2.5% per year in South Africa and Lesotho respectively. This implies that there is an annual rise in the contribution of road transport to environmental degredation in South Africa and Lesotho. In addition, Agarana *et al*. (2017) noted that the usage of high quality fuel for transportation and the construction of good road network will significantly minimize greenhouse gas emissions from transportation projects in Sub-Saharan African Cities. In Nigeria, Longe *et al*. (2018) established adopting the ARDL model in analysing impact of trade and transportation in the Nigerian environment that import transport services and GDP per capita have positive impact on CO_2 emissions in the long-run while in the short-run, trade, GDP per capita, energy consumption and transport services are capable of correcting about 74% deviation of carbon emissions back to long-run equilibrium.

From the existing empirical studies on the factors that influence the environment, notable is no consideration yet in the context of Africa for transport services in the import and export sector as an alternative proxy for Impact in the IPAT model suggested by Dietz and Rosa (1994). Rather than focusing on population impact on the environment, the study focused on trade activities, transport services in the import and export sector of the economy impact on the environment in Africa. This is done to test the alternative proxy suggested by the theorists in the context of Africa. The study make use of four different panel econometric techniques (Pooled Ordinary Least Squares method, Fixed Effect estimation, Random Effect estimation, and Pooled Mean Group estimation) to analyse the impact. These techniques were adopted in order to have a robust view of the impact of the stated phenomenon in Africa.

Table 1: Summary of Related Empirical Review

Name(s)	Variables Used	Method(s)	Study Area	Finding
Halicioglu and Ketenci (2016)	CO2 emissions per capita, commercial energy use per capita, per capita real income, square of per capita real income, and trade openness ratio	ARDL, Cointegration and GMM	Transition Countries	International trade positively and significantly impacts on environmental quality of transition economies.
Hasanov *et al.* (2018)	Consumption-based CO2 emissions per capita, Territory-based CO2 emissions per capita, Gross Domestic Product per capita, Imports per capita, Exports per capita.	ARDL, Cointegration, and GMM	Nine Oil Exporting Countries	International trade only has effect on consumption-based carbon emissions.
Huang *et al.* (2017)	Individual country import and export	Emerging Accounting Approach	China and Africa Countries	Importation of primary goods from African countries increase environmental pollution.
Kahouli and Omri (2017)	Volume of FDI between pairs of countries, incomes (GDPs), per capita GDP, similitude index, real exchange rate, trade flows, environmental degradation, inflation rate, high education, internet users, and geographical distance.	Static Estimations, Dynamic Estimations, and Simultaneous Equation System	14 origin countries and 39 host countries	Environmental degradation exhibits negative and significant effect on trade.
Kim *et al.* (2018)	CO2 emissions, trade with advanced countries (North), trade with developing countries (South), population density, urbanization, GDP per capita, GDP per capita square, and schooling.	GMM	131 developed and developing countries	Trade flow in developed countries has a positive effect on their environment.

Le *et al*. (2016)	Carbon emissions, particulate matter emissions, trade openness, real GDP per capita, and square of GDP per capita	IPS Unit Root Test, Panel Cointegration Test	98 countries	Trade openness leads to environment degradation in all income groups of countries
Saidi and Hammami (2017)	Per capita GDP, energy consumption, freight transport, per capita carbon dioxide emissions, financial development, capital stock, and trade openness	Simultaneous-Equations Models	75 Countries	Transportation has significantly impact on environmental degradation while the effect of environmental degradation on transportation is not statistically significant.
Shahbaz *et al*. (2016)	CO2 emissions (metric tons), real exports (US$), real imports (US$) and real GDP (US$)	Panel Cointegration Tests and Panel VECM Causality Test	105 countries	Trade openness reduce carbon emissions in all the panels.
Yoon *et al*. (2018)	International trade flows, transport costs, export taxes, tariffs, market price, carbon emissions and total output	Multi Regional Input–Output Analysis, and Structural Decomposition Analysis	14 Countries	Transportation services has positive effect on carbon emissions changes.
Xu *et al*. (2018)	Transportation GHG emissions, population density, land use mix, road connectivity, bus accessibility, shape compactness, shape complexity, family size, household income, average age of family, household education level, willingness to walk, willingness to bus, and willingness to bicycle.	Correlation and Path Analysis	Xiamen City, China	Population density, land use mix, road connectivity, and bus accessibility are sources for urban residents' transportation GHG emissions
Agarana *et al*. (2017)	Amount of money invested in acquiring a unit of mass transit equipment, amount of money spent on salary of mass transit workers, amount of money spent on maintaining vehicles, amount of money spent on acquiring other means of transportation, value of extra time used in terms of money, money to produce high quality fuel, amount spent on acquiring hybrid or electric cars, cost of making most	Linear programming Model	Lagos State, Nigeria	The usage of high-quality fuel and the construction of good road network works against GHG emissions in Sub-Saharan African cities

	things available close to where people live, costs of contructing good road network, cost of traffic light and other gadgets, cost of maintaining the road, cost of training people for efficient use of transport capacity, and cost of technology to increase fuel efficiency.			
Al-Mulali and Ozturk (2015)	Ecological footprint, energy consumption, urbanization, trade openness, industrial output, and the political stability and conflicts	Panel Unit Root, Panel Cointegratio n, Panel VECM and Granger Causality	14 MENA Countries	Trade Openness caused environmental degradation in the long-run.
Alshehry and Belloumi (2016)	Per capita transport carbon emissions, per capita road transport energy consumption, and per capita real GDP	Unit Root, Bound Testing Approach, and Granger Causality Test	Saudi Arabia	Road transportation energy consumption leads to environmental degradation in Saudi Arabia
Arvin *et al*. (2015)	Transportation intensity, per-capita air transportation activity for freight, per-capita air transportation activity for passengers, carbon dioxide emissions from transport per capita, the extent of urbanization, and real per-capita economic growth	Panel Vector Auto-regressive Model	G-20 Countries	There is a long-run significant link between transportation intensity and carbon emissions in G-20 countries.
Bokpin (2016)	Natural Resources Depletion, Forest Reserve depletion, Foreign Direct Investment, Institutional and Governance Quality, GDP, Level of urbanization, and Level of domestic Investment.	Fixed and Random Effect, and Robust OLS	African countries	FDI negatively impact on environmental degradation in Africa
Boutabba *et al*. (2018)	Carbon emissions, energy consumption, real GDP per capita, Per capita intermediate goods exports, Per capita non-intermediate goods exports, Per capita intermediate goods imports, Per capita non-intermediate goods imports, Per capita total intermediate goods trade, and Per capita total non-intermediate goods trade	Panel Unit Root, Panel Cointegratio n, Dynamic OLS, Panel Causality Test,	17 Sub-Saharan African Countries	Trade in intermediate goods positively impact on carbon emissions in Sub-Saharan African Countries.

Chaturvedi and Kim (2015)	Global primary energy consumption, global emission in MTC, electricity generation in	Global Change Assessment Model	Global	The use of electricity-based public rail transportation system reduces carbon emissions.
El-Fadel and Bou-Zeid (1999)	Conventional pollutants emissions, carbon emissions, and fuel consumption.	IPCC Reference Approach	Lebanon	Fuel quality regulations and other policies will cause transportation GHG emissions to reduce by 31% in 2020.
Ertugrul *et al*. (2016)	Carbon emissions, real income, the square of real income, energy consumption and trade openness	Zivot-Andrews unit root test, Cointegration bound test, and VECM Granger Causality test	Top Ten Emitters in Developing Countries	There is co-integration relationship between trade openness and carbon emissions in seven emitting developing countries.
Shahzad *et al*. (2017)	Carbon Emissions (CO2), Energy Consumption (ENG), Trade Openness (TRD) and Financial Development (FIN)	ARDL bound test	Pakistan	Trade openness Granger cause carbon emissions in Pakistan.
Tongwane *et al*. (2015)	Fuel Efficiency (L/Km), Net Calorific Value of the fuel (TJ/L), Carbon emission factor(ton C/Tj), Cabon stored, fraction of carbon-dioxide	IPCC Tier 2 Approach	South Africa and Lesotho	Road transport contributes to environmental degradation
Campbell *et al*. (2018)	er capita energy consumption, total population, light-duty-diesel, heavy-duty-diesel, and light-duty-gasoline	Technology Driver Model (TDM) approach,	United States	The negative effect of transportation sector on U.S. air quality will reduce in the future.
Hossain (2012)	CO_2, Energy Consumption, Trade Openness, Per capita GDP and Urbanization	VECM and GMM method	Japan	Trade openness negatively impact carbon emissions in the long-run.
Wang *et al*. (2014)		Descriptive Statistics	China	China's Transportation sector will cause a future increase in carbon emissions
Choi and Roberts (2015)	GDP from transportation sector in the state, number of workers in the state, number of establishments in the state, All petroleum consumption by transportation sector in the state, thousands of barrels of oil, CO2 emissions by fuel combustion in the transportation sector measured in MMT	Malmquist Environmental Productivity Index	United States of America	Carbon emissions reduction has positive effect on transportation productivity in the United States.

3. Methodology and Data Used

The study adopted the extended model of Ehrlich and Holdren (1971) IPAT by Diet and Rosa (1994), Dietz and Rosa (1997), York et al. (2003), Aguir-Baragaoui, et al., (2014) and da Silva, et al., (2019). They used this simple formulation to investigate the interactions between populations, economic growth and technological development. They established that the model is more effective on assessing production technological efficiency and identifies variables that contribute to environmental degradation. However, their study is differentiated in terms of the variables considered to have technological impact. However, for the purpose of this study, Dietz and Rosa (1994) theoretical framework on the IPAT model is adopted and modified.

Dietz and Rosa (1994) explains the impact of population, affluence and technology on the environment. Where I is the environmental impact, P is population, A is per capita economic output (referred to as affluence) and T is the impact of per unit activity (referred to as technology). The model is written as:

$$I = P^*A^*T \quad (1)$$

In typical application purpose, Dietz and Rosa (1994) explained that data are obtained on Impact, Population and Affluence to solve for T, which is the technology used. The model is specified as:

$$T = I/(P^*A) \quad (2)$$

Considering the importance of the stochastic term in the model, Dietz and Rosa (1994) reformulated the model in a stochastic form:

$$I = aP^bA^cT^de \quad (3)$$

I, P, A and T remain environmental impact of population growth, per capita economic activity and impact per unit economic activity. For the model, b, c and d are the parameters, while a and e are residual terms. To estimate these parameters, Dietz and Rosa (1994) submitted that data on I, P, A and T can be used.

This study modifies Dietz and Rosa (1994) argument of the IPAT model by incorporating trade and transport services as factors that influence environmental degradation in Africa and included some other variables that may contribute to environmental degradation in the continent. The model for this study is specified as:

$$InCO_{2t} = \alpha_0 + \beta_1 T_t + \beta_2 InGDP_t + \beta_3 InE_t + \beta_4 TRE_t + \beta_5 TRI_t + \varepsilon_t \quad (4)$$

From equations (4), $InCO_{2it}$ implies log form of carbon emissions (kt), a proxy for environmental degradation, T_{it} is trade captured as the ratio of trade to GDP, $InGDP_{it}$is log form of gross domestic product per capita (at current \$US), $InEU_{it}$ is the log form of energy use in Kg oil equivalent per capita, TRE and TRI are transport services proxies. Where TRE_{it} is transport services as a percentage of commercial services export, TRI_{it} is transport services as a percentage of commercial services import. All the data are sourced from World Development Indicators (2018). The sampled countries are listed in Appendix 1. The countries were selected by region depedning on the availability of data and their contributions to the region development. ε_{it} is the error term, i represents countries included in the study, all at time t. α_0 is the model intercept, while $\beta_1 - \beta_5$ are the coefficients of the parameters.

Before formulating the estimated model for the study, the variables were subjected to panel unit root test in order to be aware of their mean reverting ability in the long-run and also verify if there is need for long-run cointegration analysis. To verify this, the study adopted panel unit root of Im *et al*. (2003) hereafter refered to as IPS, and panel unit root test of Pesaran (2005). These tests are adopted given their superiority over Levin and Lin (1993), Levin *et al*. (2002) and Breitung (2002) which does not take into consideration heterogeneity condition in the autoregressive coefficients. The IPS equation is stated as follows:

$$\Delta y_{i,t} = \alpha_i + \rho_i y_{i,t-1} + \sum_{j=1}^{p} \emptyset_{i,j}\, \Delta y_{i,t-j} + \varepsilon_{i,t};\ i = 1, 2, \dots, N;\ t = 1, 2, \dots, T, \quad 5$$

$y_{i,t}$ represents each variable used in the model, α_i expalins individual fixed effect. In order to avoid uncorrelated residuals overtime, p is selected using optimal lag selection criterion, and a common p is used across group. i denotes the group, N is the number of observations, T is the timeframe taking into consideration all the group members. The model is tested towards two hypothesis: null and the alternative hypothesis. The null hypothesis is tested as $\rho_i = 0$ for all i, versus the alternative hypothesis: $\rho_i < 0$ for some $i = 1, \dots, N_1$ and $\rho_i = 0$ for $i = N_1 + 1, \dots, N$ (Bangake and Eggoh, 2012).

For country specific, the IPS statistic is used based on average Augmented Dickey Fuller (ADF) statistics. The model is writen as:

$$\bar{t} = \frac{1}{N} \sum_{i=1}^{N} t_{iT} \quad 6$$

t_{iT} is country specific ADF regression where $\bar{t}$ is the t-statistic, while the N and T values has been provided in Im *et al*., (2003).

Due to the shortcoming of the IPS test assuming cross-section independence of variables in line with first generation panel unit root test, the test is criticised. It was established in literature that cross-section dependency is as a result of some unobserved variables (such as: externalities, regional and macroeconomic linkages and unaccounted residual interdependence) not accounted for in the model (Bangake and Eggoh, 2012). On this note, second generation panel unit root tests to bridge this shortcoming were introduced. Among this test, the most popularly used: Cross-Sectional Augmented IPS (CIPS) presented by Pesaran (2005) is adopted for this study. Pesaran (2005) stated the model as:

$$\Delta y_{i,t} = \alpha_0 + \rho_i \Delta y_{i,t-1} + \delta_i \bar{y}_{t-1} + \sum_{j=1}^{k} \delta_{ij} \Delta \bar{y}_{i,t-j} + \sum_{j=0}^{k} \Delta \bar{y}_{i,t-j} + \varepsilon_{it} \qquad 7$$

$\bar{y}_{t-1} = \left(\frac{1}{N}\right) \sum_{i=1}^{N} y_{i,t-1}$, $\Delta \bar{y}_t = \left(\frac{1}{N}\right) \sum_{i=1}^{N} y_{it}$, and $t_i\ (N,T)$ is the t-statistic of the estimate of ρ_i in the above equation used for computing the individual ADF statistics. More precisely, Pesaran proposed the following test CIPS statistic that is based on the average of individual CADF statistics as follows:

$$CIPS = \left(\frac{1}{N}\right) \sum_{i=1}^{N} t_i\ (N,T) \qquad 8$$

The critical values for CIPS for various deterministic terms are tabulated by Pesaran (2005).

Having specified the unit root model of the study, the next is to formulate the cointegration model of the variables. The study adopts Pedroni (1999) cointegration test which takes into consideration heterogeneity factor. According to Pedroni (1999), the first step is to compute the difference between the observed value of the dependent variable and the predicted value which is referred to as the residuals from the hypothesized cointegrating regression. The panel heterogenous cointegration model takes the form:

$$InCO_{2it} = \alpha_0 + \delta_i t + \beta_1 T_{it} + \beta_2 GDP_{it} + \beta_3 InE_{it} + \beta_4 TRE_{it} + \beta_5 TRI_{it} + \varepsilon_{it} \qquad 9$$

$$For\ t = 1, \dots, T, i = 1, \dots, N;$$

The study reformulate equation 4 using Pooled Mean Group (PMG) Panel ARDL equation model to capture the long-run and short-run impact of trade and transport services on environmental degradation in Sub-Saharan Africa countries. The model is formulated as:

$$\Delta InCO_{2it} = \vartheta_0 + \sum_{q=1}^{n} \rho_1 \Delta CO_{2it-k} + \sum_{q=1}^{n} \rho_2 \Delta T_{it-k} + \sum_{q=1}^{n} \rho_3 \text{InGDP}_{it-k} + \sum_{q=1}^{n} \rho_4 \Delta InE_{it-k} + \sum_{q=1}^{n} \rho_5 \Delta TRE_{it-k} + \sum_{q=1}^{n} \rho_6 \Delta TRI_{it-k} + \beta_1 CO_{2it-1} + \beta_2 T_{it-1} + \beta_3 GDP_{it-1} + \beta_4 InE_{it-1} + \beta_5 TRE_{it-1} + \beta_6 TRI_{it-1} + \delta ecm_{it-1} + \varepsilon_{it} \quad 10$$

From equation (3), the Δ denotes the changes in the variables in the short-run, n is the optimal lag length, ε_{it}- error term at time. The parameters ρ $(i = 1, 2, 3, 4, 5, 6)$ are the corresponding long-run multiplier, and the parameters $\beta = (1, 2, 3, 4, 5,$ and $6)$ are the short-run dynamic of the PMG/AR model. δecm is the parameter estimate of the error correction model.

4. Results

A descriptive analysis of the data used was first carried out to examine the behaviour of the variables over the period. In table 2, we have 315 number of observations in the study. The result showed that the mean values of the variables behaved within their minimum and maximum values. Also it can be deduced from the result that carbon emission, trade, transports services in the export and import sector, energy consumption and economic growth averagely changes at 4%, 74.6%, 24.2%, 44.5%, 2.8% and 3.3% respectively within the period studied. From the table also, it was noted that the most of the variables (carbon emission, trade ratio to GDP, transport service in the export sector, energy consumption and GDP) are not normally distriubted except for transport services in the import sector as it has a probability value greater than 5% significance level.

Table 2: Panel Descriptive Statistics

Variables	No of Obs	Mean	Maximum	Minimum	Jarque-Bera
CE	315	44730.57	503112.40	656.39	2093.51*
T	315	74.58	152.55	19.46	12.80*
TRE	315	24.24	93.35	0.70	85.42*
TRI	315	44.53	87.86	10.44	16.06
E	315	840.22	3369.03	113.42	241.38*
GDP	315	19460.66	466572.80	158.41	5592.25*

Note: * implies significance level at 1%

Source: Compiled by Authors

Prior to the empirical estimate discussion, there is need to attend to the preliminary analysis of the variables which include panel unit root test. Although, the panel data estimators [Pooled Ordinary Least Squares (POLS), Fixed Effect, Random Effect and Hausman Effect, Pool Mean Group (PMG)] are suitable for estimation irrespective of the order of integration of the stationary status of the data used, except for I(2) condition. However, in order to justify the study or the data is free of this condition, all the panel unit root test [Common unit root (LLC, Breitung) and Individual effect (IPS, Fisher ADF, Fisher PP)] were used. The panel unit results in table 3 show that all the variables compromise at I(0) and I(1). This implies that there is problem of unit root among the variables and there is need to test if a long-run cointegration exist among them. To do this, the Pedroni Panel cointegration test is employed.

Table 3: Panel Unit Root Test

Variables	*LLC*		*Breitung*		*IPS*		*ADF*		*PP*	
	Level	**First Difference**	**Level**	**First Difference**	**level**	**First Difference**	**Level**	**First Difference**	**Level**	**First Difference**
InC	-0.61	-6.21	0.84	-3.78	1.68	-3.69	28.30	81.73	50.38	218.79
	(0.27)	(0.00)*	(0.80)	(0.00)*	(0.95)	(0.00)*	(0.95)	(0.00)*	(0.18)	(0.00)*
T	-5.79		-0.19	-6.70	-2.51		72.22		64.41	
	(0.00)*		(0.43)	(0.00)*	(0.01)*		(0.00)*		(0.01)*	
TRE	-3.37		-0.21	-4.87	-0.24	-5.37	46.81	103.87	58.58	
	(0.00)*		(0.42)	(0.00)*	(0.41)	(0.00)*	(0.28)	(0.00)*	(0.05)**	
TRI	-6.39		-2.72		-1.63		56.38		83.17	
	(0.00)*		(0.00)*		(0.05)**		(0.07)***		(0.00)*	
InE	-1.74		0.99	-5.01	0.32	-5.11	40.24	102.43	59.35	
	(0.04)**		(0.84)	(0.00)*	(0.62)	(0.00)*	(0.55)	(0.00)*	(0.04)**	
InY	-2.46		-0.71	-4.05	1.15	-7.44	31.78	137.76	28.07	207.00
	(0.01)*		(0.24)	(0.00)*	(0.87)	(0.00)*	(0.87)	(0.00)*	(0.95)	(0.00)*

*, **, *** 1%, 5%, 10% implies level of significance. The parenthesis ( ) implies te prob. Values.

Source: Compiled by Authors

Panel Cointegration Test

From Pedroni panel cointegration test result in table 4, it was revealed that the variables have a long-run conitegrating relationship as the panel PP-Statistics and ADF statistics, and Group PP-Statistics and ADF-Statistics are significant at 1%. This implies that the variables can be estimated.

Table 4: Pedroni Panel Cointegration Test

Tests	**Statistics**	**Prob.**
Panel v-Statistic	0.6549	0.2562
Panel rho-Statistic	2.9016	0.9981
Panel PP-Statistic	-19.141	0.0000
Panel ADF-Statistic	-9.8917	0.0000
Group rho-Statistic	5.5134	1.0000
Group PP-Statistic	-9.0069	0.0000
Group ADF-Statistic	-5.2110	0.0000

Source: Compiled by Authors

Panel Results

The result in table 5 presents the Pooled Ordinary Least Squares (POLS), Fixed Effect (FE), Random Effect (RE) and Pool Mean Group (PMG). The POLS result confirms that trade has a significant negative impact on Africa environment at 1%, export and import transport services positively impact on the environment. Energy consumption positively and significantly influence the African environment at 1% significance level, while economic activities impact on the environment is negatively insignificant. The Hausman test is significant at 5%. This implies that the random effect result should be rejected for the fixed effect. As a result of this, the fixed effect result was interpreted. From the result, trade increases environmental degradation in Africa at 1% significant level, export and import transport services negatively influence environmental degradation, but insignificant. Energy consumption and economic growth significantly increase environmental degradation in Africa.

From the PMG result, the study confirmed that in the long-run, trade, export and import transport services, energy consumption and economic activities positively impact on environmental degradation in Africa, but transportation services in the import sector is less significant. In the Short-run, trade activities in Africa reduces environmental degradation at 5% significant level, while transportation via import activities insignificantly reduces environmental degradation. Transport services in the export sector and economic activities increases environmental degradation condition in Africa in the short-run, but the impact is insignificant. However, energy consumption significantly increase the quantum of environmental degradation in Africa. The error correction result showed that the independent variables have the capacity of correcting about 42% of environmental degradation deviations from the equilibrium in short-run back to equilibrium in the long-run at 5% significant level.

The results confirmed that in the long-run where trade activities are expected to increase, more environmental is expected. Carbon emission would be stimulated by an increase in mobility demand by people and for goods and services. This mobility demand will increase the demand for energy which majority would still suffice around fossil fuels. For the FE although the transport services showed a negative effect towards carbon emission but insignificant in the African continent following the age of the mode of transportation services. The transit sector is evolving with recent transportation means such as Bus Rapid Transit (BRT) (for public use), e-ridesharing (such as Uber, Bolt, Opay e.t.c), light rail systems (an intra state transport mode) for the purpose of delivering goods and meeting human and business services. However, a notable environmental impact of these means is that they are energy-efficient means and follow transporatation policies compared to the conventional mode of tranportation, therefore their contribution to environmental degradation is expected to be insignificant. The FE result also justifies the significance of the PMG result on transport services.

The findings from this study deviates from other studies considering the mean analysis used in explaining the phenomenon. While previous studies (El-Fadel and Bou-Zeid, 1999; Boutabba, *et al*., 2018; Bokpin, 2016; Halicioglu and Ketenci, 2016; Huang, *et al*., 2017; Le, *et al*., 2016; Shahbaz, *et al*., 2016; Yoon, *et al*., 2018 among others) found an exert effect of trade on environmental degradation, the findings is mixed, which implies that trade and transport services impact on environmental degradation is significant considering the activities channel between countries.

Table 5: Panel Estimation Result

$Variables$	T	TRE	TRI	InE	InY
$POLS$	-0.007	0.003	0.002	1.623	-0.030
	(0.000)*	(0.088)***	(0.400)	(0.000)*	(0.571)
FE	0.002	-0.0002	-0.001	0.347	0.410
	(0.000)*	(0.564)	(0.114)	(0.003)*	(0.000)*
RE	0.002	-0.0002	-0.0011	0.388	0.401
	(0.000)*	(0.700)	(0.088)***	(0.001)*	(0.0000)*
Hausman test	**Chi-Sq. Statistic**		**Chi-Sq. d.f.**		**Prob.**
	11.061		5		(0.050)**
Pool Mean Group Long-run Effect					
$Variables$	T	TRE	TRI	InE	InY
	0.002	0.002	0.0004	0.634	0.136
	(0.000)*	(0.000)*	(0.254)	(0.000)*	(0.000)*
Short-Run					
$Variables$	ΔT_{t-1}	ΔTRE_{t-1}	ΔTRI_{t-1}	ΔInE_{t-1}	ΔInY_{t-1}
	-0.001	0.001	-0.0003	1.038	0.033
	(0.042)**	(0.400)	(0.696)	(0.011)**	(0.583)
ECM_{t-1}	-0.424				
	(0.023)**				

*, **, *** 1%, 5%, 10% implies level of significance. The parenthesis ( ) implies the probability values.

Source: Compiled by Authors

5. Conclusion and recommendation

The study investigates the impact of trade activities and transport services in line with alternative proxy to check the impact of human activity on the environment in Africa using data from 21 countries. The study adopted four different econometric techniques: Pooled Ordinary Least Squares (POLS) Method, Fixed Effect (FE) method, Random Effect (RE) method and the Pooled Mean Group (PMG) technique, for the year 2000 to 2014. The POLS revealed that trade negatively and significantly reduce environmental degradation in Africa, while transport services in the export and import sector and energy consumption increase environmental degradation in the African environment, while economic growth reduces environmental degradation. For the FE result, trade, energy consumption and growth positively impact on environmental degradation in Africa, while transport services in the import and export sector negatively impact on environmental degradation in Africa. For the PMG, findings show that in the long-run, trade, transport services (export and import), energy consumption, and economic growth positively impact on environmental degradation in Africa. In the short-run, trade and transport services in the import sectorcontribute negatively to environmental degradation, while transport services in the export sector, energy consumption and economic growth positively impact on environmental degradation in Africa. The study therefore concludes that the impact of trade and transport services on the African environment is dynamic. This implies that, the influence depends on the nature of activities carried out in different countries. While some are working towards environmental improvement, some are working against it. From the findings, the study recommends that for the continent to achieve a sustainable environment without impeding on its growth via reduction of the usage of fossil fuel which has a larger content of emission, there is need to increase the use of energy efficient products or technologies.

Considering the proposed Africa Continental Free Trade Agreement (AfCTA) in the continent, there should be a policy designed for scrapping or removing older tranportation modes that contributes more to degradation of the environment. There is need for the continent to have stringent environment policies couples with its trade activities in order to achieve its sustainable enviroment goals. This can be achieved by adopting similar policies in the developed countries where incentives are granted on importation of goods that meets their environmental standards. Lastly, harmonisation between the continent and others on inclusion of environmental provisions in their bilateral and regional trade agreements is a significant strategy to adopt for the improvement of the environment via trade and transportation modes.

The study is therefore limited in terms of data availabilty. It can be further worked on by considering a comparison between net oil exporting and import countries in Africa and developed countries. Also, other modifications suggested by Dietz and Rosa (1994) can further be tested in the African context with consideration of other theretical studies cited in the literature review section.

Appendix 1: List of sampled countries

Sub Region	Countries
West Africa	Nigeria, Benin, Ghana, Niger, Senegal, Togo
North Africa	Egypt, Libya, Morocco, Sudan, Tunisia
East Africa	Tanzania, Kenya, Zambia, Mauritius
Southern Africa	Botswana, Namibia, South Africa
Central Africa	Angola, Central Africa Republic, Gabon

Source: Compiled by Authors

UTICAJ TRGOVINSKIH I TRANSPORTNIH USLUGA NA ŽIVOTNU SREDINU U AFRICI

Apstrakt: Ova studija istražuje uticaj trgovine i transportnih usluga na životnu sredinu u Africi. Korišćeni su i analizirani sekundarni podaci za 21 zemlju za 2000. i 2014. godinu pomoću tehnika POLS, FE, RE i PMG. Ove tehnike su otkrile raznolike rezultate. Hausmanov test je korišćen za odlučivanje između FE i RE u studiji. Hausmanov test prihvata rezultat FE tehnike zbog 5% značajnosti rezultata. POLS tehnika otkriva da trgovinski i ekonomski rast smanjuje ekološku devastaciju u Africi, dok transportne usluge u izvoznom i uvoznom sektoru i potrošnja energije povećavaju devastaciju. Iz rezultata FE, trgovina, potrošnja energije i ekonomski rast pokazali su pozitivan uticaj na životnu sredinu u Africi, dok transportne usluge u uvoznom i izvoznom sektoru smanjuju devastaciju životne sredine. Za rezultat PMG-a, nalazi pokazuju da dugoročno trgovina, transportne usluge (izvoz i uvoz), potrošnja energije i ekonomski rast povećavaju ekološku devastaciju u Africi. Ovo ukazuje na na činjenicu da kako se ove aktivnosti dugoročno povećavaju, tako nema odgovarajućih mera kojima bi se poboljšao kvalitet životne sredine. Kratkoročno, trgovinske i transportne usluge u uvoznom sektoru smanjuju devastaciju, jer većinom uvoza dominiraju poboljšani tehnološki proizvodi, dok transportne usluge u izvoznom sektoru, potrošnja energije i ekonomski rast utiču na životnu sredinu u Africi. Studija zaključuje mešoviti efekat trgovine i transportnih usluga na životnu sredinu u Africi. Glavna preporuka je da se u Africi koriste energetski efikasnije tehnologije za postizanje cilja održivog okruženja, a to se može postići pregledom trgovinske politike kako bi se podstakao priliv poboljšane tehnologije u ekonomije.

Ključne reči: Trgovina, transportne usluge, upotreba energije, ekonomski rast, devastacija životne sredine

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